This folder also contained 2 blueprints that were too large to scan.

THE HISTORY OF
THE DISTRIBUTION OF DIRECT CURRENT
IN THE CITY OF BALTIMORE

WRIGHT G. CALDER

University of Maryland
College Park, Maryland
January 9, 1936.

SYNOPSIS

While Baltimore was yet in the stage of development, its first electric company, Brush Electric Light Company of Baltimore City, was organized(1881). The same courage and integrity required in the organizing and financing of such a venture was responsible for its survival of the many smaller and less courageous companies organized after the trail had been opened. Although the name of the original company has faded into oblivion as a result of mergers and consolidations, it has been the nucleus of the present Consolidated Gas Electric Light and Power Company of Baltimore City.

The first electric current for ordinary house lighting in Baltimore was alternating current, while direct current at 500 volts was used for power. As the city grew, however, distribution of domestic current became a problem solvable at that time only by the Edison Three-Wire D. C. Net Work. This system was installed and the McClellan Street sub-station erected just before the Baltimore fire of 1904. The fire proof building and the underground net, however, were practically undamaged and are serving the original territory today.

Long distance transmission of electric current soon necessitated alternating current generation. As no suitable A. C. distribution system was then known, it was necessary to convert the A. C. to D. C. at the sub-stations. Rotary machinery was best suited for this purpose, but because A. C. machinery was more economical and of simpler construction, therefore less expensive initially, efforts were made to replace the D. C. net by a similar A. C. system. As a result, an A. C. network was superimposed upon the the old Edison about 1933, and since that time it has been a Company policy to prevent the growth of D. C. use by making practically all new installations of A. C. equipment and replacing all faulty D. C. equipment with the newer service.

FOREWORD

The author expresses his sincere appreciation to Mr. L. G. Smith, Assistant to General Superintendent, Consol. G. E. L. & P. Co., for his assistance in gathering technical data for Part III, and to Doctor Frederick C. Ruths, Gas Division of the Consol. G. E. L. & P. Co., for his file of the publications from which the major portion of the subjective and illustrative material was taken.

Thanks are also due to Miss Frances E Jenkins for the use of her reference books, for the large Baltimore Map, and for her assistance in electrical history; Miss Elizabeth Diggs for her painstaking efforts in the typing; Miss Alice Reynolds, Librarian, Consol. G. E. L. & P. Co., for her interest and aid in the use of the Company library; and Mr. G. W. Fogg, Reference Librarian, University of Maryland (College Park) for making available the facilities and resources of the University Library.

The author is especially indebted to the Consolidated Gas Electric Light and Power Company of Baltimore City for the release of load curves and illustrative material for this thesis not otherwise available.

W. G. C.

CONTENTS

INTRODUCTION

The history of the distribution of direct current in Baltimore divides itself immediately into three major parts; a history of incorporations and consolidations leading to the organization of the present electric power company, a history of electric service in Baltimore, and a history and desciption of the system now used in Baltimore for distibuting direct current to its consumers.

Little information is available concerning D. C. alone, so the history of electric service is treated in a general way and the reader is asked to realize that D. C. profited by many of the general installations and modifications as well as by the strictly D. C. changes.

Needless to say, many technical details have been omitted entirely from this thesis; books have been written to discuss them. It is hoped, however, that the reader will get from this paper a clear mental picture of the distibution system for direct currents in Baltimore.

Much more could be written about the companies that form the present consolidation, but this treatise is to be of an informative nature and for that reason much desciption and discourse are excluded.

The picture would be incomplete without some historical treatment of the city itself. Many pages could well be spent in describing the romantic early life of this industrious tide-water town and its development into the thriving city it now is. The technical nature of the topic restricts this phase of the discussion, however, and just a bare account of its younger days escape the "blue pencil".

PART I

INCORPORATIONS AND CONSOLIDATIONS

EARLY BALTIMORE

The town of Baltimore in 1816 hugged the waterfront, crowding as much of itself as possible about the wharves, and very grudgingly pushed its extremities landward. Truly it was an amphibious animal. Its population was about 56,000 and was increasing at the rate of from 16,000 to 20,000 every ten years, while its nearest rival of 39,000 rambled along at 8,000 to 10,000. New York, Philadelphia, Baltimore, Boston and Charleston, in the order named, were the only cities which the statisticians of that day deemed worthy of consideration.

* "Baltimore, at that period, had three important subdivisions--theoretical subdivisions, to be sure, but none the less subdivisions--the names of which have been handed down from generation to generation and are not unfamiliar today. There was Baltimore town or Baltimore section; there was Old Town, and there was Fell's Point. These three (at one time separate settlements) had been merged and in 1816, in fact for many years prior to that time, were a part of the city of Baltimore." The old Baltimore section is now the business center; Old Town is the section immediately east of the Fallsway and Gay Street; Fell's Point, named for William Fell, the early settler, is that extensive section on the north side of the inner harbor, the center of which was Broadway and Thames Street.

Around these sections Baltimore expanded slowly to reach the ten square miles indicated on the map. As was indicated above, the town was one of the leaders in the United States (the first to innaugurate a gas company) and by the end of the nineteenth century was "quite a berg". Gas was then widely used for heat and light in homes, hospitals,

*Baltimore As It Was In 1816 - Wilbur F. Coyle, City Librarian.

business houses, factories, and for street lighting.

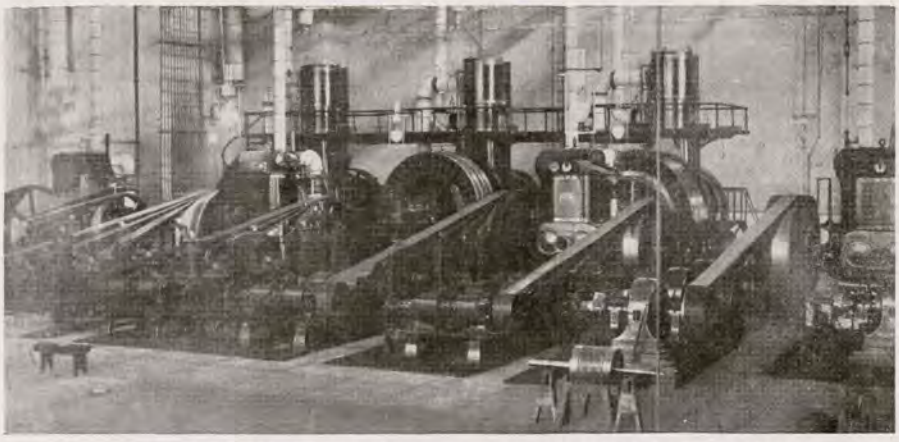
BALTIMORE'S FIRST ELECTRIC COMPANY

"In 1878," in the words of Thomas Edison, "I went down to see Professor Baker, at Philadelphia, and he showed me an arc lamp--the first I had seen. Then a little later I saw another--I think it was one of Brush's make--and the whole outfit, engine, dynamo, and one or two lamps, was traveling around the country with a circus. At that time Wallace and Moses G. Farmer had succeeded in getting ten or fifteen lamps to burn together in a series, which was considered a very wonderful thing."

The first electric company in Baltimore was the Brush Electric Light Company of Baltimore City operating at the Monument Street Station. To organize and finance such a venture required much courage and a like amount of faith in the enterprise, and these qualifications were found in the group of men who incorporated the Brush company in 1881; viz., Summerfield Baldwin, Edgar G. Miller, Oliver C. Zell, Isaac Brooks, Jr., William T. Levering, Edmund D. Bigelow, Dr. William Whitridge, Jacob B. Waidner, George H. Baer, Charles D. Fisher.

EARLY COMPETITORS.

After the ice was broken the less courageous and more speculative business men of Baltimore were encouraged to enter the field, and many smaller companies started up in competition with the original company. Of course, there was very little profit for such a number of small companies and on October 20, 1885 they were all merged to form the United States Electric Power and Light Company of Baltimore City, Brush's lone competitor, with the plant at the Center Street Station. The following year the two companies were merged under the name of the original organization and everything went along smoothly.



An Interior of Brush Electric Light Co. Station, at Monument and Constitution Streets in 1896.

At Monument Street in the Nineties

Mr. Chattin Writes of the Facilities and Organization of the Brush Company

ASSOCIATED RECIPROCAL EXCHANGES

One Park Avenue,
New York.

Mr. John G. Reese,
Consolidated Gas Electric Light & Power Co. of Balto.

Dear Mr. Reese:

I have your letter of June 18th and the copy of the Gas and Electric News for June and was very much interested in reading the article regarding the old Brush Electric Co. In looking over the pictures I, of course, do not recognize anybody in the first picture which undoubtedly was taken quite sometime before I joined the force in March, 1895. In the picture showing the night inspectors and troublemen I recognize the face of the man at the extreme left who I think was named Martin Houck, and at the time I was at the Brush Co. he drove the wagon with the line gang. The faces of the others in this group are not familiar to me, although the fellow with his hand pointing upward somewhat resembles "Chick Sales" of the specialist fame.

In the picture taken in Annapolis I recognize Charles Gantz at the extreme right hand of the top row. At the time I worked at the Brush, Charlie was in charge of the line gang.

During the two years that I worked for the Brush, Edward Baker was general superintendent, William Slemmons was chief engineer, Jake Slemmons, his brother, was machinist, Pete Slaffer was also a machinist, Charlie Roder repaired arc lamps, Walter Rumpp and myself took care of inside electrical repairs, although Walter Rumpp left in 1896 while I continued on until March, 1897.

Last night while looking over my scrap book I came across a picture of the interior of the Brush Station taken by a friend of mine on a Sunday in February, 1896, and I am sending you this, thinking it may be of interest. This picture shows the three one-thousand horse-power steeple compound Westinghouse engines direct connected to ten thousand light alternators. These units were part of the exhibit at the World's Fair at Chicago, but the dynamos were rewound and somewhat changed before delivery to Baltimore. The operating voltage was 2750 instead of 2300 at Chicago. In those days we spoke of these as 7200 alternation machines, today it would be sixty cycles.

The four Westinghouse compound engines shown in the foreground went through the 1893 fire and some at least were in operation in the ruins in less than forty-eight hours after the fire. All that was done to them at that time was to straighten the rod connecting the eccentrics with a rocker arm. During 1895 and 1896 the burnt cylinders on these engines were gradually replaced. You will note that three of these engines are driving six sixty-light Brush arc machines, three being tandem belted to each driving pulley. The engine at the extreme right is driving five Westinghouse D. C. arc machines. These were supposed to be seventy-five light machines, but it is my recollection that we were never able to get quite as much load as that on any of them. The armature resting on the horses is a spare one for the Westinghouse machine. It was my job to keep the electrical apparatus inside the station, with the exception of arc lamps, in good repair.

I hope this long tale has not bored you, but the article in the Gas and Electric News stirred up my recollections. I certainly wish to thank you for your thoughtfulness in writing me about the matter.

Engineering Department
W. J. Chattin, *Manager.*

On October 2, 1893, however, the Wenstrom Electric Company of Baltimore City was incorporated. Shortly afterward (Dec. 23, 1895) the Edison Electric Illuminating Company of Baltimore City was incorporated, followed by a rapid succession of other companies with franchises and business (usually with the principal asset a nuisance value) to sell. This condition continued until May 6, 1899, when all the companies except the Wenstrom consolidated, resulting in the formation of the United Electric Light and Power Company. Later on February 14, 1905 these two companies merged with the Consolidated Gas Company of Baltimore City under the name of Consolidated Gas Electric Light and Power Company of Baltimore.

PRESENT GAS AND ELECTRIC COMPANY

This latter organization assumed the name which it has carried through its rapid rise to its enviable position in Baltimore industry.

*"In the years immediately following (the last consolidation), the total electric load, including the street lighting service, was approximately 6000 KW. The service, which was chiefly A.C., was generated by machines of the revolving armature type. At Monument Street the single phase 133 cycle - 2300 volt - A & B side or double generator machines were directly connected with reciprocating steam engines. The armatures were keyed to the same shaft 90 degrees out of phase. This is the origin of the two phase electric system. These units had been previously exhibited at the World's Fair in Chicago in 1893. The street lighting equipment consisted of Brush arc light generators for 9.6 ampere

*The Company's Electric System During 25 years - Richard H. Lang, Chief Operator, Electric Stations Department.

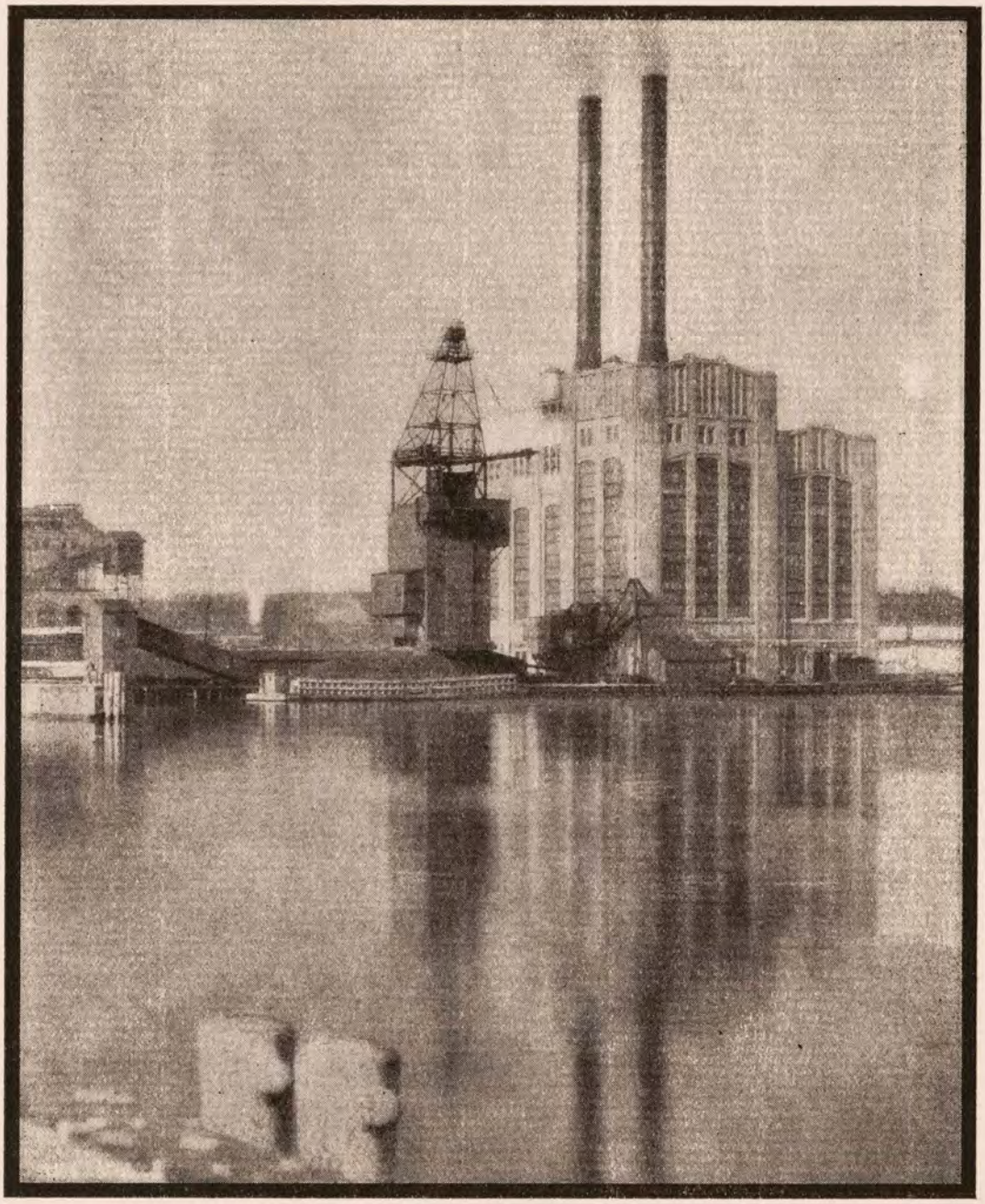
carbon lamp service. Six or eight of these units were belted to other reciprocating engines by means of a countershaft. The voltage per arc circuit was about 5000 volts. D. C. service at 250 volts was supplied from generators at Monument Street for elevators and other power service in the downtown district. At Penn Street Station, Wood arc machines were belted to a line shaft with a mechanical clutch at each end, connected to 750 H. P. steam engines. This arrangement provided a certain degree of reliability. Several 150 H. P. engines with arc machines on each side were also used at this station. At the Center Street station there were several A. C. reciprocating units and six or eight Wood arc machines."

The company's total personnel at that time numbered about 150 men, and company offices were located at the Continental Building.

THE RATE WAR

With no small "nuisance" companies, service was good and rates were maintained at a lower level than in cities of similar size to Baltimore. But on October 5, 1904, the Baltimore Electric Power Company of Baltimore City was permitted to enter the field. This company launched its uncertain career which resulted in a disastrous rate war unsettling the electric light and power business, crippling progress, and impairing service. May 4, 1907 saw this company merge with the Maryland Telephone and Telegraph Company of Baltimore City to form the Baltimore Electric Company of Baltimore City with its plant at Gould Street.

Like many of its predecessors, however, the company showed a deficit and was forced to enter into a nine hundred and ninety-nine



A Pulverized Fuel-Burning Plant Generating Electricity at Tide-Water

The initial installation in the Gould Street Station of the Consolidated Company is 96,000 horse-power. The ultimate installation will be 192,000 horse-power.

The Gould Street plant burns pulverized coal. It is interconnected with the Consolidated's large steam-driven station at Westport, with the hydroelectric and steam development of the Pennsylvania Water and Power Company on the Susquehanna River at Holtwood and will be interconnected with the new hydroelectric development at Safe Harbor now under construction.

year lease to the Consolidated on November 20, 1907. The promoters had entered into an agreement with the public authorities not to consolidate (an example of the insincerity of competition) and were only too glad to take advantage of this opportunity for relief when the time arrived.

THE BALTIMORE FIRE

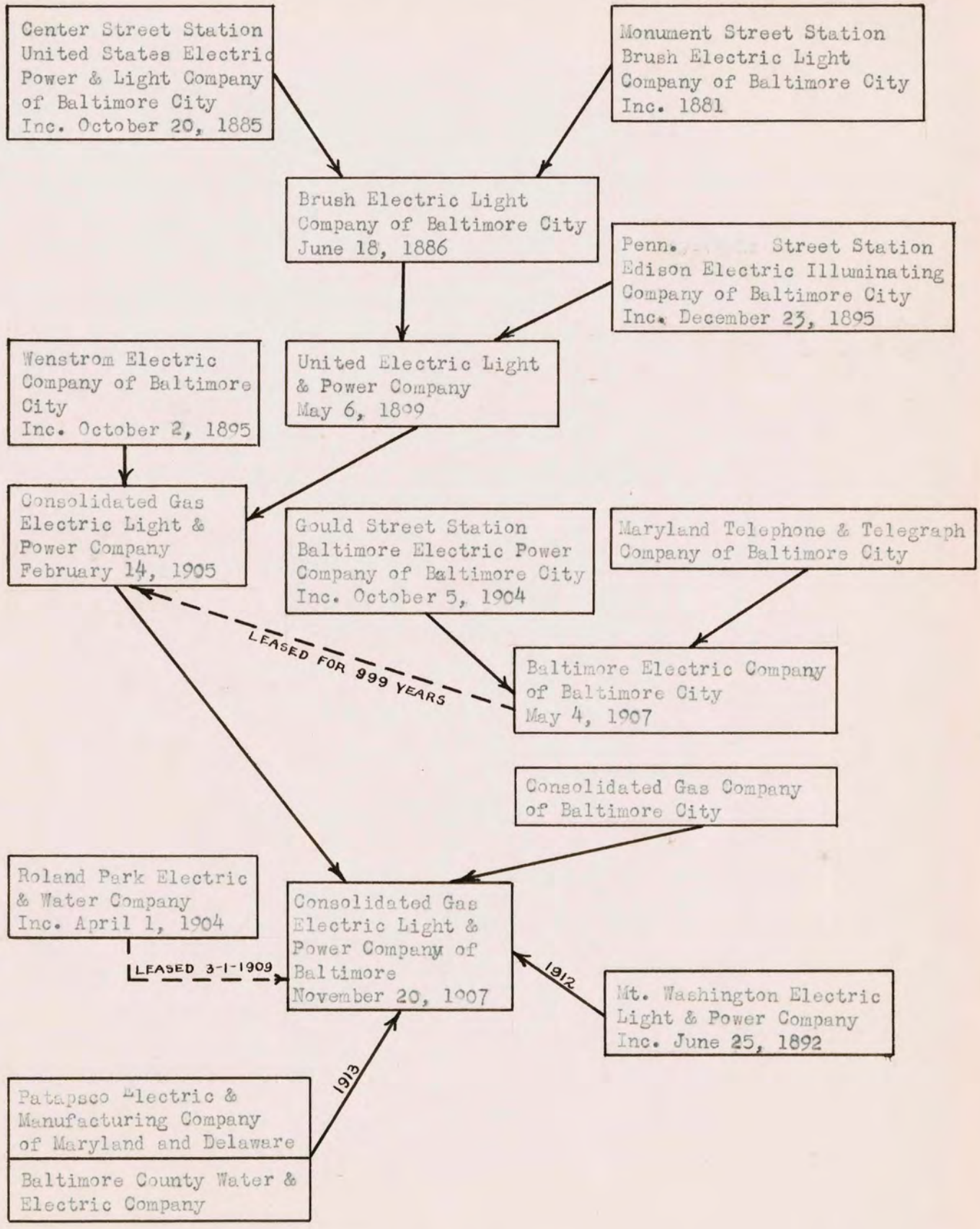
In 1903 the famous Edison system, an underground D. C. distribution network, was installed and the McClellan Street building constructed for its supply. The latter was built as a completely fireproof structure. A few days before it was due to be initially operated the Baltimore fire of February 7, 1904 razed the whole business district of Baltimore. The storage battery equipment at the Continental Building and the overhead transmission and feeder systems in the fire zone were completely destroyed.

But the fire proof building and the underground network were little affected and went into service almost immediately after the fire. 25 cycle alternating current supplied from Pratt Street at 13,000 volts was transformed into direct current by four 1200 KW Westinghouse rotary converters and fed to the network supplying the entire central section of the city, formerly Baltimore section.

During the period of rebuilding in the fire zone and reorganization of commercial policies along with the expansion of the system itself it was necessary to warp a steamer to the wharf at Pratt Street station to furnish the additional steam required for the increased electrical load.

From this point on the Consolidated Gas Electric Light and

INCORPORATIONS AND CONSOLIDATIONS



(Consolidated Gas Electric Light & Power Company of Baltimore and Its Constituent Companies---Charters, Mortgages and Releases as of July 1, 1910.)

Power Company advanced in every respect with its "avowed purpose ... to become the strongest and most useful servant of the people in building a greater Baltimore." More individual customers were gained, more different uses occurred for its products, and as a result the company expanded its personnel and property and extended its services.

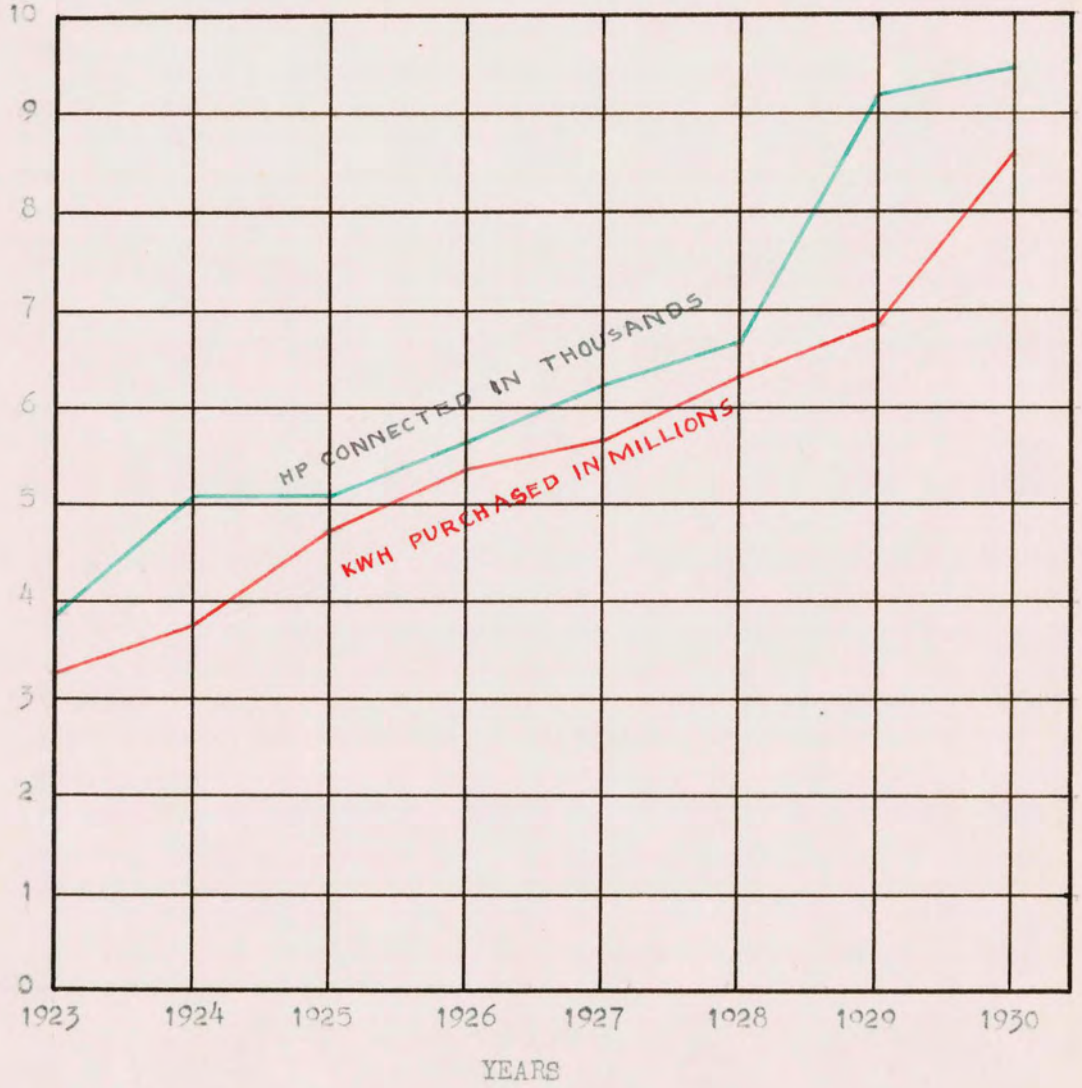
CONTINUED GROWTH

Local power plants were abandoned one by one and replaced by light, heat and power from Consolidated's central plant. Out standing customers signing contracts for these services in 1912 include: the Baltimore Gas Appliance Company, manufacturers of gas appliances; W. H. Crawford & Company, spice manufacturers; Industrial Building Company, manufacturing building; Baltimore Tube Company, brass tubing factory. Total new installation for 1912 was 8,381 H. P. The next year was not so fat but after that customers and central station service increased until in 1924 Baltimore was more thoroughly electrified through central service than any other city in America. This growth is indicated by the chart below.

Having acquired practically all the service in the city proper the Company's agressive business policy soon reached out to include suburban and county districts. The Roland Park Electric and Water Company, incorporated April 1, 1904 was leased to the Company in 1909; the Mount Washington Electric Light and Power Company, incorporated June 25, 1892, was absorbed in 1912; and in 1913 two smaller companies (Patapsco Electric and Manufacturing Company of Maryland and Delaware, and Baltimore County Water and Electric Company) came under the parent organization.

GRAPH SHOWING LOCAL POWER PLANT ABANDONMENT IN OFFICE BUILDINGS

Con. G. E. L. & P. Co.- Baltimore, Md.

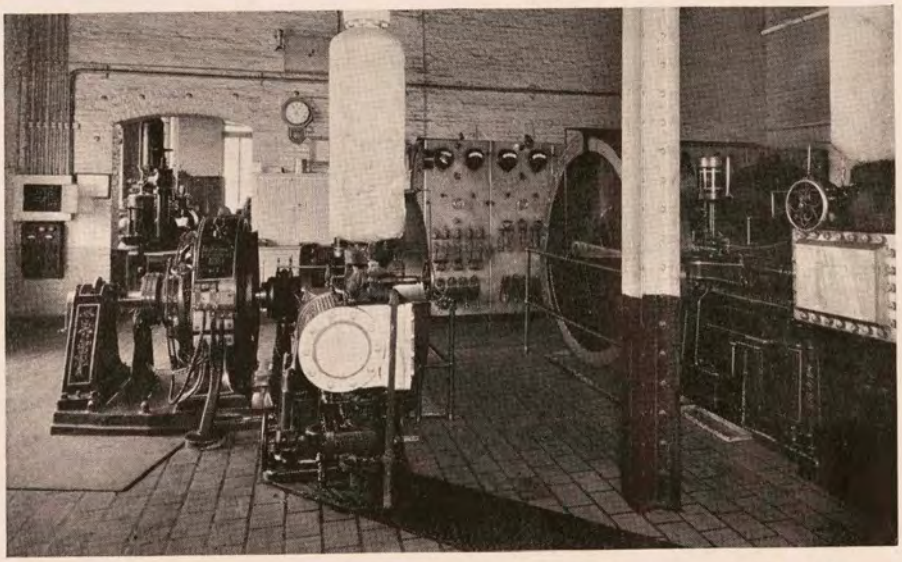


(1930 Data Based On 6 Months)

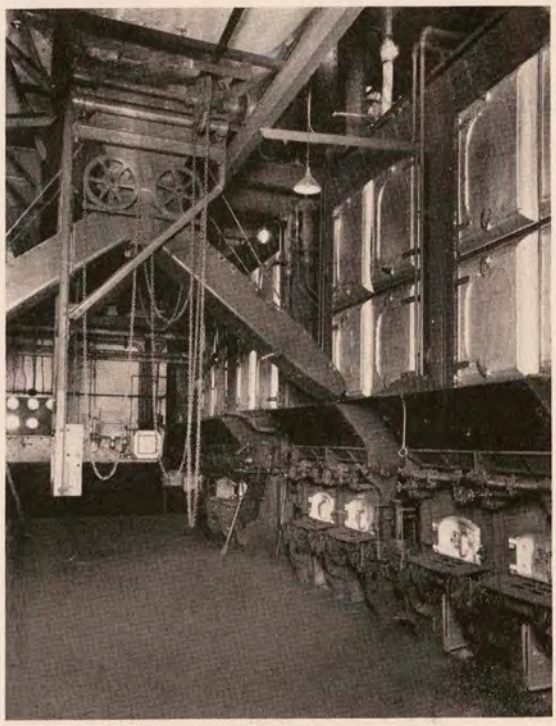
Power Pictorial #18

ELECTRIC OPERATIONS

Year	No. of Customers	Current Sales (Kilowatt-Hours)
1910	16,605	42,881,697
1915	41,237	145,390,026
1920	79,469	377,613,364
1925	158,608	645,215,639
1930	221,567	830,563,939



Part of the abandoned power plant at City Hospitals, showing some of the engine generator equipment.



A view in the boiler room. In the future, this plant will be used for heating purposes only and will no longer generate steam to make electricity.

In 1910 hydro-electric power was contracted for by Mr. Aldred, president 1910-15, from the Pennsylvania Water and Power Company at Holtwood, in Pennsylvania, and later the Consolidated built the Safe Harbor Plant eight miles up the Susquehanna River from Holtwood. This plant was developed to supply all the power required by the recent electrification of the Pennsylvania Railroad, from Havre de Grace to Washington. These two hydro plants and the steam plant, also at Holtwood, are interconnected and operate in effect as a single development, the largest in North America.

Officers

Consolidated Gas Electric Light and Power Company of Baltimore

J. E. ALDRED, *Chairman of the Board*
Chairman of the Board since 1910; also President from 1910 to 1915.

HERBERT A. WAGNER, *President*
President since 1915; Vice-President from 1910 to 1915.

CHARLES M. COHN, *Vice-President*
Vice-President since 1910.

CHARLES E. F. CLARKE, *Vice-President*
Director since 1910; Vice-President since 1915.

WM. SCHMIDT, JR., *Secretary & Treasurer*
Secretary since 1910; also Treasurer since 1926.

The Lexington Building

Modern offices in the heart of the city make the Company's display rooms of gas and electric appliances convenient to its customers.

The main offices and stores are in the twenty-one story Lexington Building which the Company built in the heart of the shopping district of Baltimore.

It is one of the tallest and best office buildings in Baltimore.

IN THE HEART OF BALTIMORE'S BUSINESS DISTRICT

The circle indicates the Company's Building where its General Offices and Display Rooms are located.

PART II

ELECTRIC SERVICE IN BALTIMORE

ELECTRIC SERVICE

In the early history of current distribution in Baltimore, as in most other central systems, the first direct current was generated at 500 volts and was used just for power. In the Edison Three-Wire system this would place 250 wolts between the neutral wire and each of the outside (positive and negative) wires with the full 500 across the two outside wires.

At this time all house and lighting current was alternating current, but there was no satisfactory distribution system for A. C. to correspond to the Edison Three-Wire network for direct current. Then, too, the alternating current was of 25 cycle frequency and therefore unsatisfactory for lighting purposes.

McCLELLAN STREET STATION

So in 1904 the Consolidated installed rotary converters at McClellan Street to supply the new Edison network with 120/240 volts direct current for lighting service. In 1907 Consolidated's only competitor, the Baltimore Electric Company of Baltimore City, installed three 1000 KW motor-generator sets at the Sharp Street Station and started a D. C. sub-station on Madison Street east of Eutaw. Their generating station was located at Gould Street where three 2000 KW three phase 60 cycle 6600 volt Westinghouse turbine driven generators supplied current to Sharp Street. On November 20, 1907, this company was leased to the parent organization for 999 years.

WESTPORT STATION

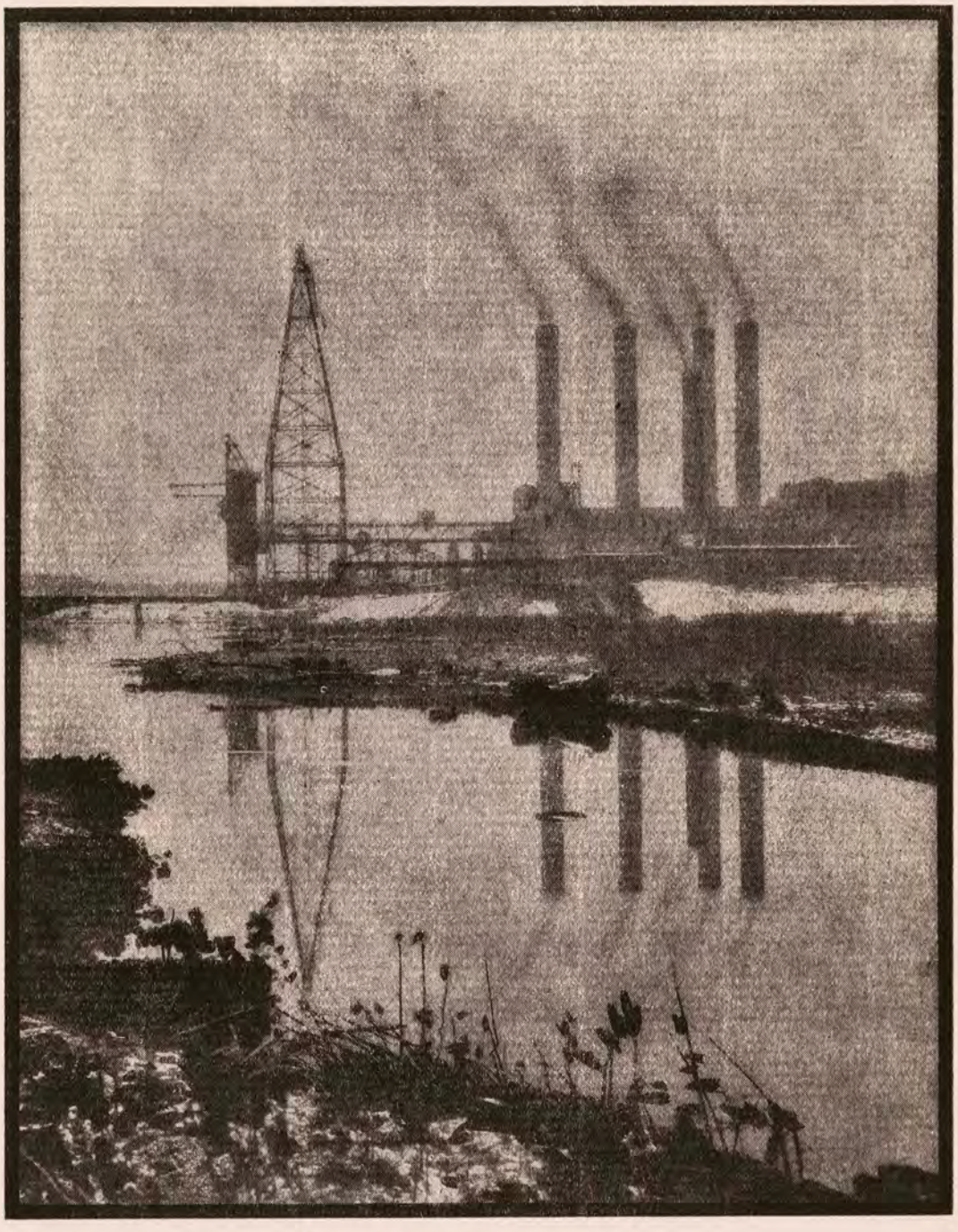
In June, 1906, the Westport generating station was started with equipment similar to that at Pratt Street; viz.,four 2000 KW 25 cycle 13000 volts G. E. alternators driven by 3000 H. P. McIntosh and Seymour reciprocating engines. Tie cables were installed from Westport to McClellan Street, Penn Street and Monument Street. The latter two were made sub-stations and equipped with 1000 KW and 500 KW frequency changers for 62½ cycle service. Center Street station was shut down and later abandoned.

A 5000 KW engine driven generator was installed at Westport increasing the generating capacity from 8000 KW to 13000 KW. A 5000 KW G. E. vertical turbine driven generator was also installed (1908) but later abandoned.

GRIFFIN'S COURT

For several years prior to this time a section of the city around south Broadway had been receiving alternating current service from a transformer station on Griffin's court just off Eastern Avenue. In order to supply this section with direct current a sub-station known as Broadway was erected directly opposite the transformer station on Griffin's Court, and received twenty-five cycle 13000 volt service from McClellan Street. This was converted to A. C. by two 500 KW rotary machines.

In the same year, the first G. E. Mercury Arc rectifiers were operated at Monument Street and Penn Street to supplement the Brush arc machines at Monument Street to meet the ever increasing street lighting load.



Westport Electric Generating Station

The steam turbines at Westport have a capacity of 221,000 horse-power which with the Consolidated's other plants give a total installation of 346,000 horse-power.

The system is interconnected with the hydro steam electric plants of the Pennsylvania Water and Power Company at Holtwood. It will be interconnected with the new hydroelectric development at Safe Harbor now under construction.

TIME OF INSTALLATION OF

D.C. EQUIPMENT

McClellan Alley Substation

Rotary Converters

1903	-	#2	-	1200 kw.
1903	-	#3	-	1200 kw.
1903	-	#4	-	1200 kw.
1906	-	#5	-	1200 kw.
1907	-	#6	-	2000 kw.
1912	-	#1	-	2000 kw.
1922	-	#7	-	4300 kw.

Storage Batteries

#1	-	1911
#2	-	1923

Custom House Avenue

Rotary Converters

#1	-	1918	-	2000 kw.
#2	-	1918	-	2000 kw.
#3	-	1920	-	2000 kw.
#4	-	1926	-	4300 kw.

Storage Batteries

#1	-	1922

Franklin Substation

Rotary Converters

#1	-	1924	-	2500 kw.
#2	-	1924	-	2500 kw.
#3	-	1930	-	3185 kw.

OTHER CHANGES

In 1907 the A. C. load at Sharp Street was transferred to McClellan Street and the 6600 volt 60 cycle service was gradually changed over to 4000 volts and 62½ cycles to conform with the service of the frequency changers at Monument Street and Penn Street stations.

The Gould Street station was shut down and its generators sold to a mining concern in Mexico.

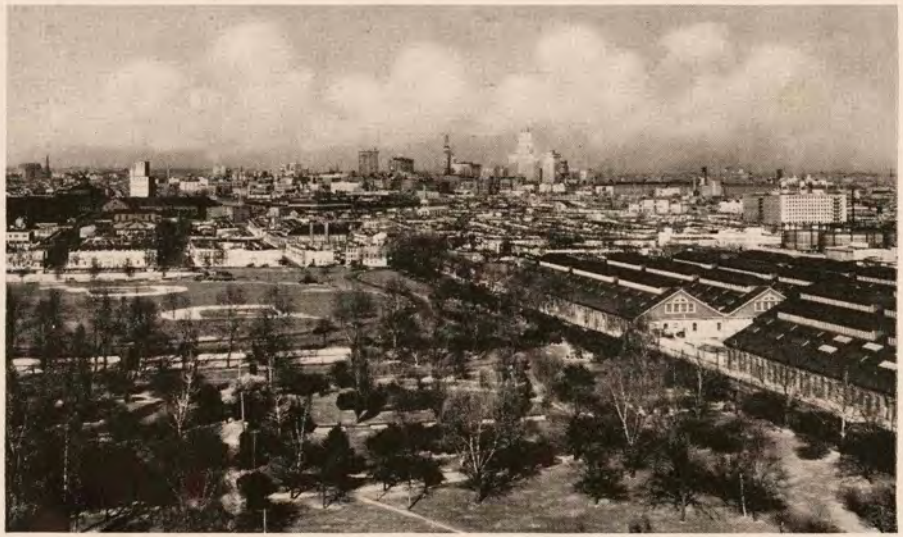
The Mt. Washington Electric Light and Power Company was taken over in 1912 and its Falls Road generating station was made a sub-station, supplied from Monument Street. The service was then changed from 2300 volt 3 phase 3 wire to 4000 volt 3 phase 4 wire to conform with city service.

PUBLIC SERVICE COMMISSION

Following the rate war of 1907 and the consequent disturbed business situation the Public Service Commission was created in 1910. With its chief function "the exercise of supervision over the Company's relations with the public and the issuance of its securities" the commission soon placed the central electric distribution business on a sound and stable basis.

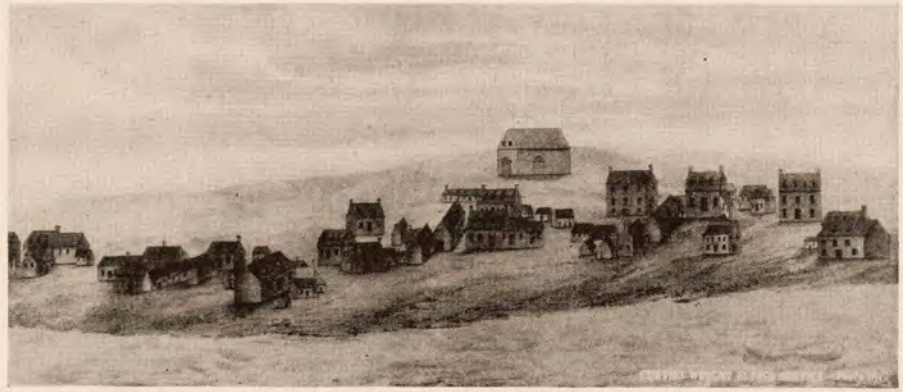
HYDROELECTRIC SUPPLY

As Baltimore grew its industries grew in number but crowded in an unproportionally small area, which gave rise to other problems; namely, greater power output from the company's limited capacity, and smoke and dirt from industrial furnaces. When the town was young there was enough capacity in the numerous and scattered power plants to take care of any peak load, and the smoke and dirt from smoke stacks of



Looking Northward from the Montgomery Ward Building, in Southwest Baltimore.

Carroll Park immediately adjoins this modern industrial building, and silhouetted against the eastern sky can be seen Baltimore's newest and most prominent skyscrapers.

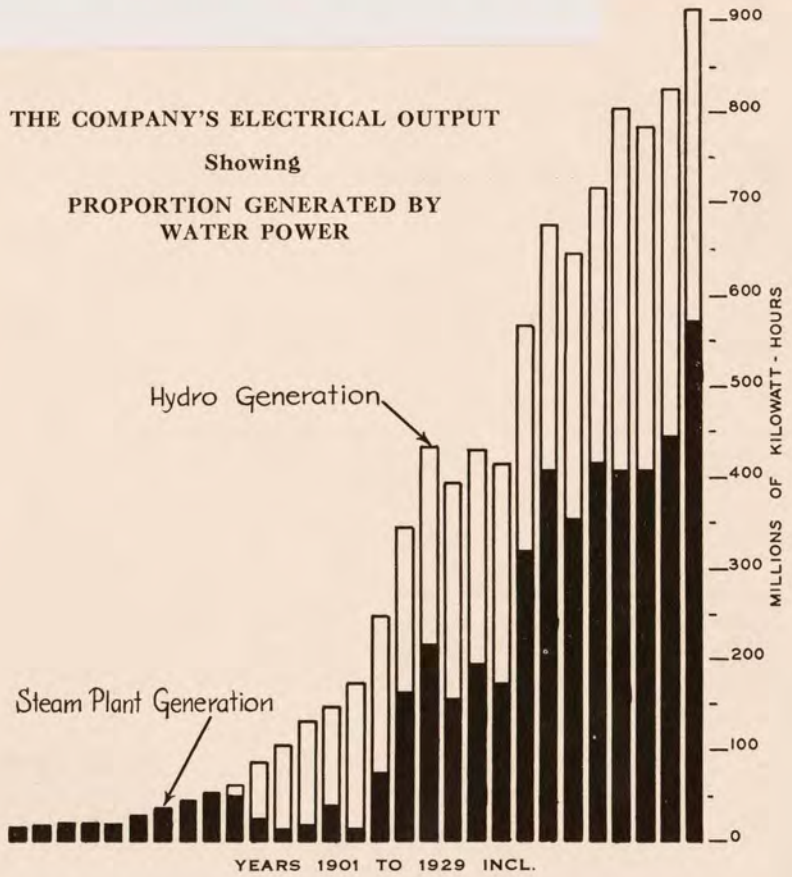


An Authentic Print of Baltimore, Circa 1730

When Baltimore had approximately twenty-five dwellings, there was no smoke problem requiring consideration. The growth of the city, however, has brought many changes.

Light Street and the Waterfront.

The density of traffic, both land and water, which is one of the problems that the modern city must face, is well illustrated in this picture. The smoke haze is an even more serious problem.



plants generating their own power (either because it was more economical than central supply or because central supply was inadequate) was hardly a critical problem.

But because of Baltimore's excellent commercial situation on the Chesapeake Bay, combined with its inherent aggressive spirit, many new industries sprang up here and the old ones expanded. There was one solution--hydro-electric supply.

HOLTWOOD POWER

* "On October 14, 1910, in accordance with a contract which had been signed previously with the Pennsylvania Water and Power Company, our Company accepted hydro-electric energy for the first time from the water power plant of that company at Holtwood, Pa. Energy was delivered to Baltimore over two 66000 volt 3 phase transmission circuits on steel towers. A transformer station of that company was located at Highland-town, from which 13,000 volt cables were run to our Company's and customers' sub-stations. The generators at Westport were finally operated in parallel with the Power Company service, which arrangement generally resulted in a saving for both companies from the standpoint of economy in generation. However, operating troubles increased. The cold weather caused a decrease in generating capacity at Holtwood, due to the formation of ice on the turbine blades, necessitating increased steam generation at Westport. Anchor and cake ice in the Susquehanna River complicated operating conditions at Holtwood. During flood seasons, the Holtwood capacity was lowered due to low head. The 40 miles of transmission line from Holtwood to Baltimore made our system subject to the effects of sleet and electrical storms. These circuits were grounded by Buzzards perching with outstretched

* Blue Book No.5

THE DEVELOPMENT AT HOLTWOOD

Electric power from this hydro-steam development of the Pennsylvania Water & Power Company has been used in Baltimore since 1910, when the river plant was interconnected with the Consolidated System. The installed capacity at Holtwood is 180,000 horse-power, of which 150,000 is in the hydro station and 30,000 in the adjacent steam station, which burns coal dredged from the river above the dam.

wings on the tower tops until the spacing of conductors was increased."

McCLELLAN STREET BATTERY

*"In 1911, a 10,000 ampere hour storage battery of the lead-acid type was put in operation at McClellan Street. It was the largest installation of the type known, and built by the Electric Storage Battery Company of Philadelphia. This battery was floated on the D. C. bus bars at all times, and would carry the entire D. C. system load during an interruption of several minutes to the A. C. supply for the rotary converters. During intervals of low frequency on the A. C. system, this battery was also useful in discharging into the D. C. system, thereby decreasing load on the 25 cycle system."

FURTHER DEVELOPMENTS

Previous to 1910 B. & O. trains were hauled through Baltimore tunnel by a belt line from a power house behind Camden Station. The trains were connected to this belt and mechanically pulled through the tunnel. In order to take care of the increasing load on this line the B. & O. erected a sub-station at Mt. Royal and purchased 13,000 volt 25 cycle service from Monument Street.

The United Railways and Electric Company augmented their Pratt Street power with hydro-electric energy from Holtwood in July, 1911. The Consolidated Company purchased the Pratt Street station and took over the supply to the Baltimore Street car company in 1921. The Pratt Street station is the center of distribution for the railway sub-stations throughout the city and is supplied from Westport and Highlandtown stations. As a generating station it is used now only for peak loads.

*Blue Book No.5.

Nunnery Lane sub-station was erected in 1912 to supply Catonsville.

Sixty-two and a half cycle service increased to justify the additional frequency changer capacity by a 2000 KW unit and a 3000 KW unit at Penn Street and Monument Street. The first 5000 KW unit was installed at the Penn Street station and additional ones were located at sub-stations as the demand increased.

Additions to the Westport plant in 1914 included: 2 horizontal G. E. turbo-generator units of 7500 KW and 15000 KW. A 20,000 KW G. E. unit was installed in 1917 bringing the total capacity of this station to 56,000 KW. Additions were made in 1918, 1919, and 1921 to increase this figure to 136,000 KW.

The present office building of the Consolidated Gas Electric Light and Power Company was erected and occupied in 1916. Located at Lexington and Liberty Streets it was one of Baltimore's outstanding landmarks. Offices, central library and sales service departments are located here.

Increased load on the 25 cycle industrial section was the next problem. In 1918, a new sub-station was erected at Canton, supplied with electrical energy at 13,000 volts from Highlandtown. * "In the latter part of 1917, auto-transformers were installed at Westport, Canton and South Baltimore Stations, which provided for the transmission of 25 cycle electrical energy at 26,000 volts to the industrial section. Four submarine cables were laid across the Patapsco River and harbor from Masonville to Canton, which when connected to the overhead circuits from Westport, closed the transmission loop between Westport and Highlandtown Stations. Taps from these feeders at Masonville were extended to the South Baltimore

*Blue Book No.5

Station, supplying that station at 26,000 volts instead of at 13,000 volts. ...

Custom House Avenue Sub-Station was put into service in 1919, in order to increase the capacity of the eastern end of the D. C. system, with two 2000 KW Westinghouse rotaries. The third machine, a 2000 KW, was put into operation later. Not until 1923 was a storage battery placed in operation at this sub-station, this being a 5250 ampere hour Electric Storage Battery Company unit.

The Philadelphia Road Sub-Station, completed in 1921, was the next addition, built to supply expected load from the Columbia Graphophone Plant on Biddle Street, and using 60 cycle electrical energy at 13,000 volts from Monument Street Station. It was later converted into a distribution center for 4000 volt 60 cycle feeders...

In December, 1922, reciprocating engine driven units Nos. 1, 2, 3, 4 and 5 at Westport were abandoned, and in 1923, Nos. 1, 2, 3 and 4 were removed in order to provide for the installation of the 62½cycle generators. No. 14 General Electric 20,000 KW 62½ cycle unit was put in service on April 26, 1924, and in August No. 13 General Electric 20,000 KW 62½cycle unit. These mark the beginning of 62½ cycle generation at Westport. The 25 cycle and the 62½ cycle systems are tied by the frequency changers and transformers at the sub-stations, so that the interchange of power between systems is permitted. To date the resulting generating capacity (25 cycle and 60 cycle) at Westport is 168,000 KW.

In 1923, the service in the South Broadway section from the Broadway Sub-Station was changed from D. C. to A. C.--62½ cycles. The

two rotaries were removed to the Penn Street Station.

Early in 1924 the last Brush arc machine was abandoned at Monument Street Station. This type of equipment has been gradually replaced by mercury arc rectifiers and constant current transformers for street lighting service.

In the same year, #2 Storage Battery was installed at the McClellan Street Station. This battery of 10,500 ampere hour capacity is the product of the Electric Storage Battery Company of Philadelphia.

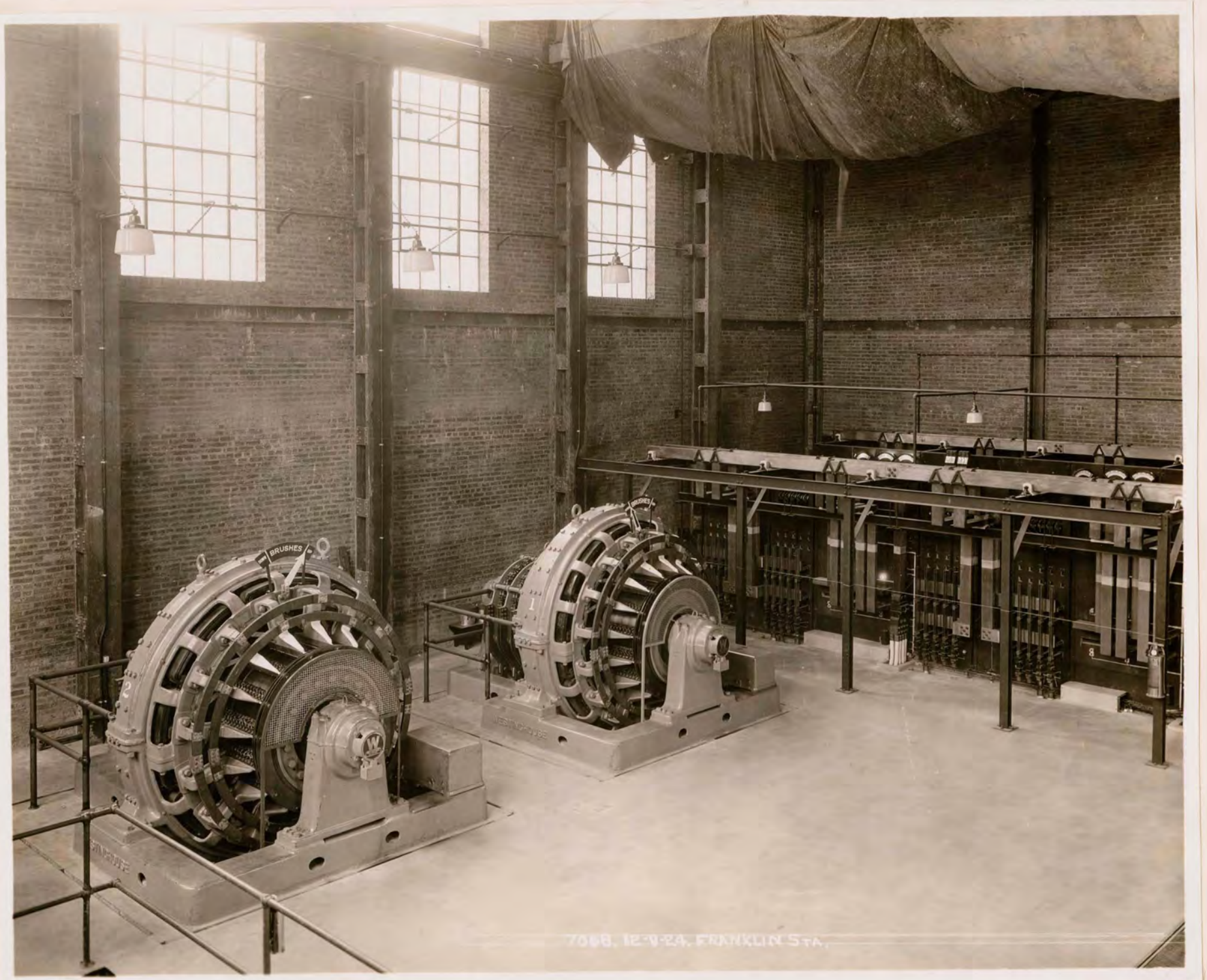
In November of 1924, two new sub-stations of our system carried load for the first time, viz.,Franklin, a D. C. sub-station, and Woodbrook Ave., a substation with 62½cycle distribution and street lighting equipment. Both of these sub-stations are supplied with 62½ cycle service at 13,000 volts from Westport. At Franklin Station 2-2000 KW Westinghouse synchronous converters were installed to operate in connection with the D. C. network.

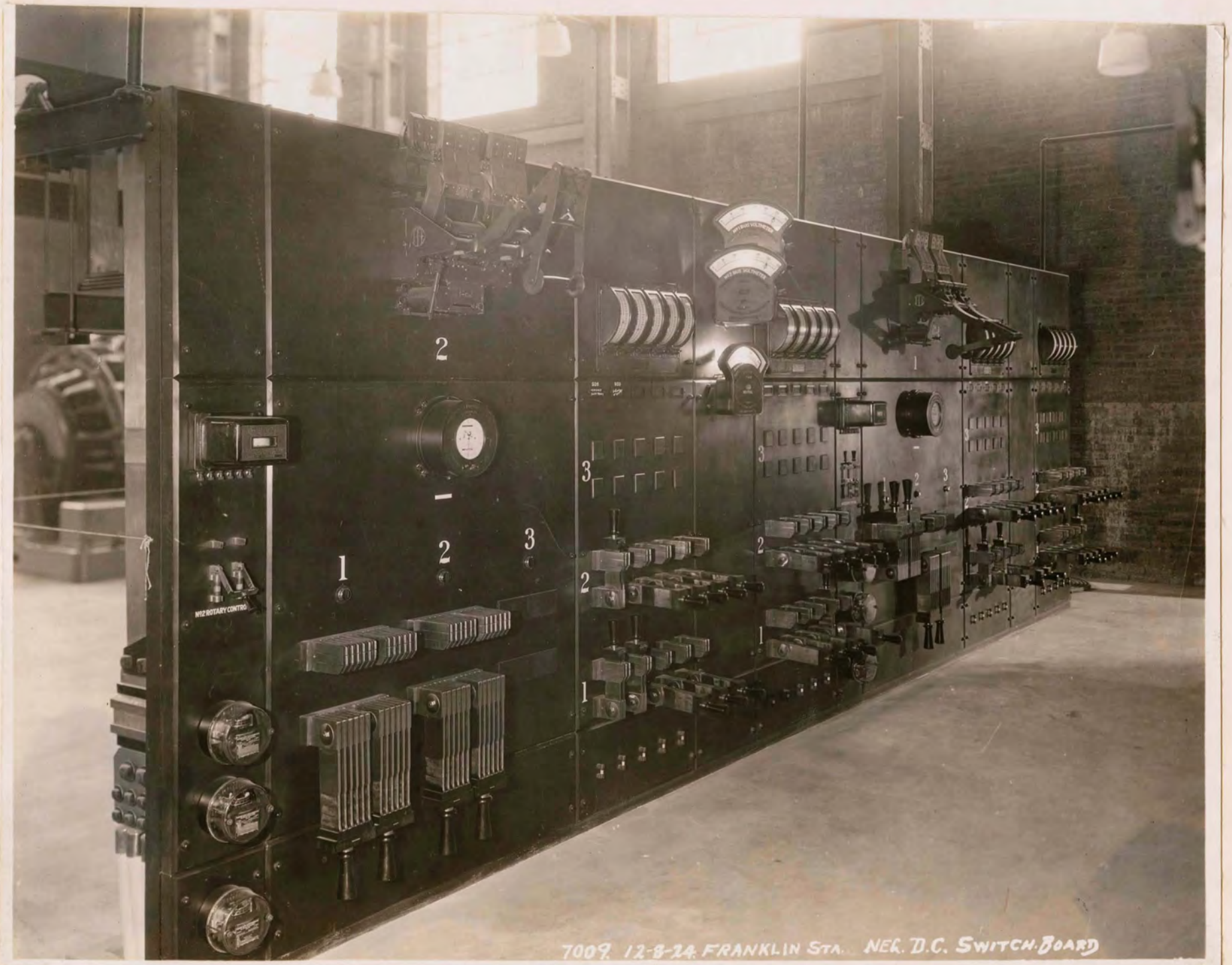
The latest addition to our electric system is the outdoor sub-station at Philadelphia Road, which was erected during the latter part of 1924. This contains a bank of 7500 K. V. A. 66,000 volt 62½ cycle transformers for the supply of electrical energy to Finksburg, Asbestos, Magnolia and Aberdeen over 1-3 phase overhead circuit on steel tower construction. This is the origin of the 66,000 volt 62½ cycle system in Baltimore and Maryland and was put in operation March 31, 1925."

Stations now feeding the D. C. network are Franklin Station, Custom House Alley, McClellan Street and Sharp Street Stations.

PENNSYLVANIA R. R. ELECTRIFICATION

During the year 1931 the Consolidated Gas Electric Light and Power Company and the Pennsylvania Water and Power Company initiated


BRUSHES
BRUSHES
7068. 12-V-24. FRANKLIN STA.

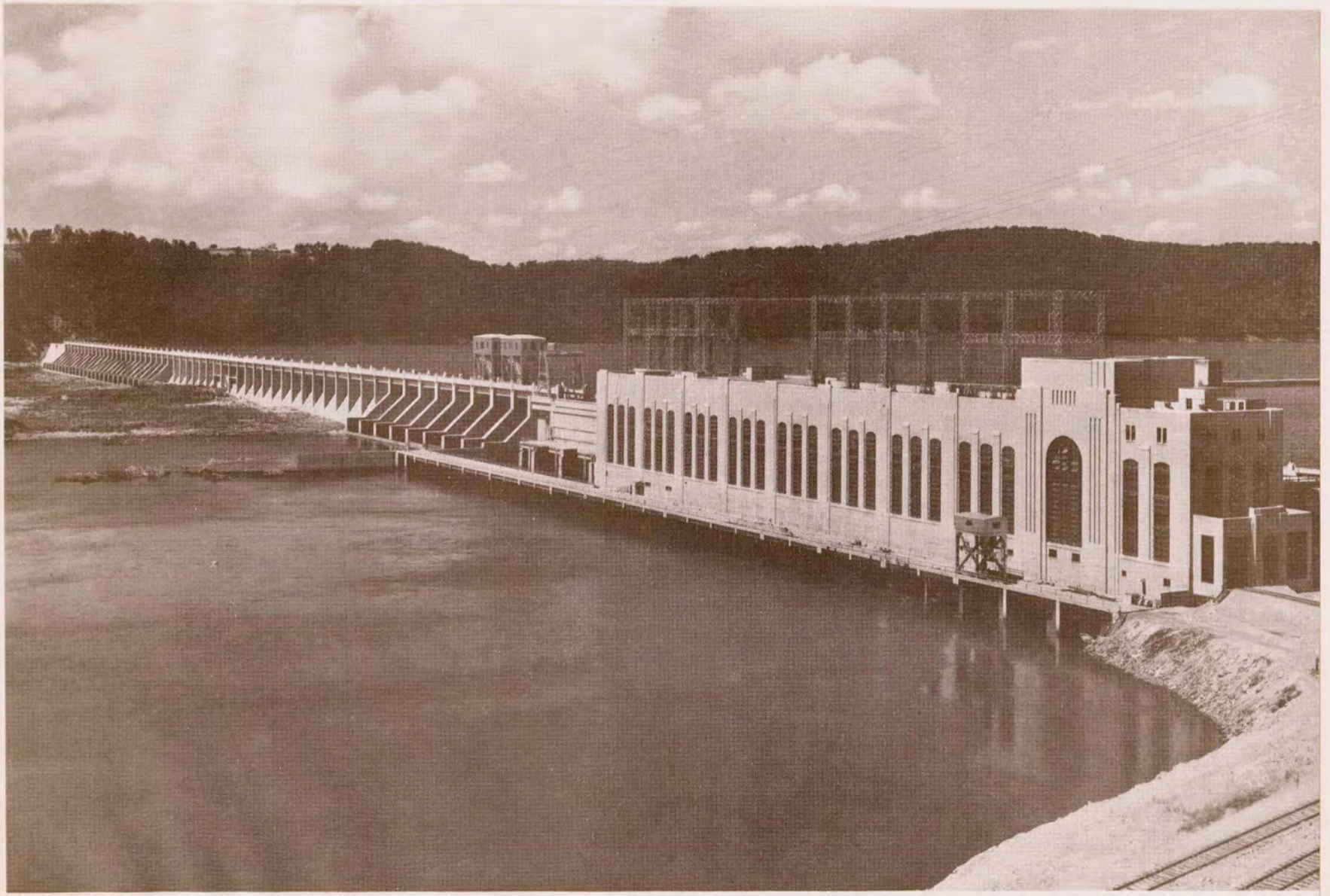


7009. 12-8-24. FRANKLIN STA. NEG. D.C. SWITCH-BOARD

the $30,000,000 development of the Safe Harbor Water Power Corporation eight miles above Holtwood on the Susquehanna River. These three companies during the year negotiated one of the largest sales of power ever made in a single contract. The agreement provided for the supply of a large part of the needs of the new electrification of the Pennsylvania Railroad from Havre de Grace to Washington for a minimum of twenty years, payments under which will ultimately reach over $4,000,000 per year.

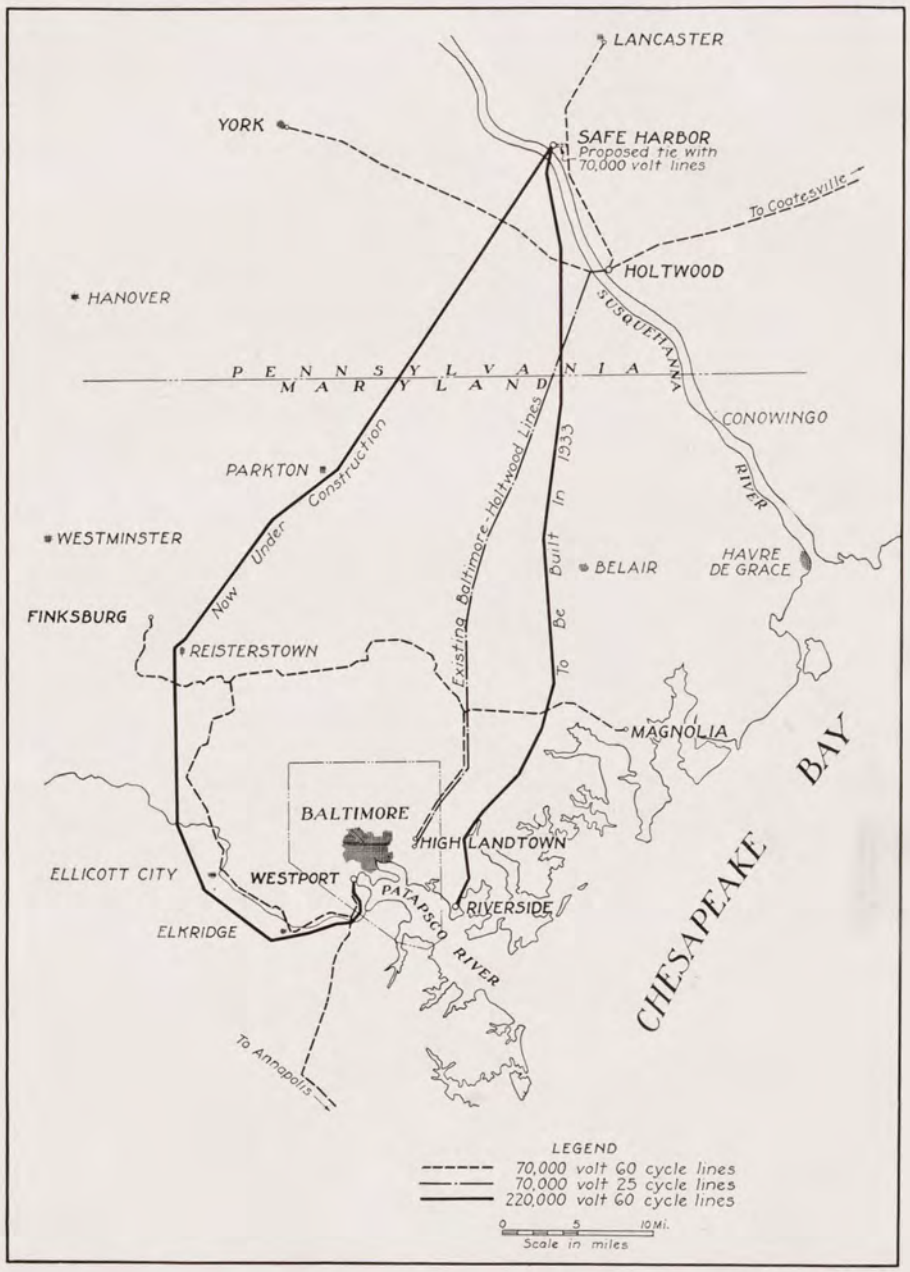
With the initial six turbines at the Safe Harbor plant (for which contracts have been awarded) the interconnected plants will have total resources of more than 750,000 horse-power, which will be increased by additional turbines, as needed, to upwards of 1,000,000 horse-power.

From this point the Consolidated Gas Electric Light and Power Company has enjoyed prosperity known to very few industries in and around Baltimore notwithstanding the recent business depression.

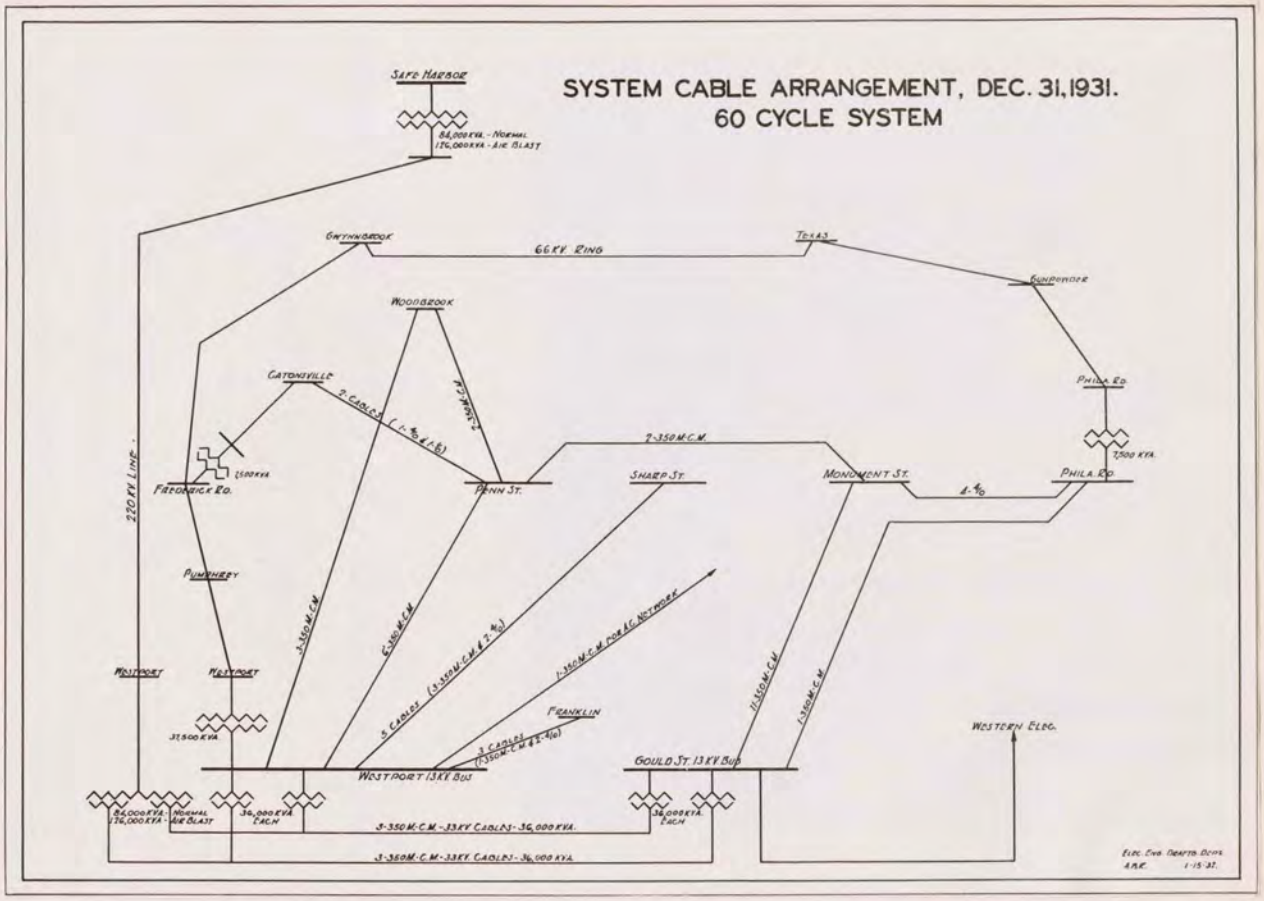


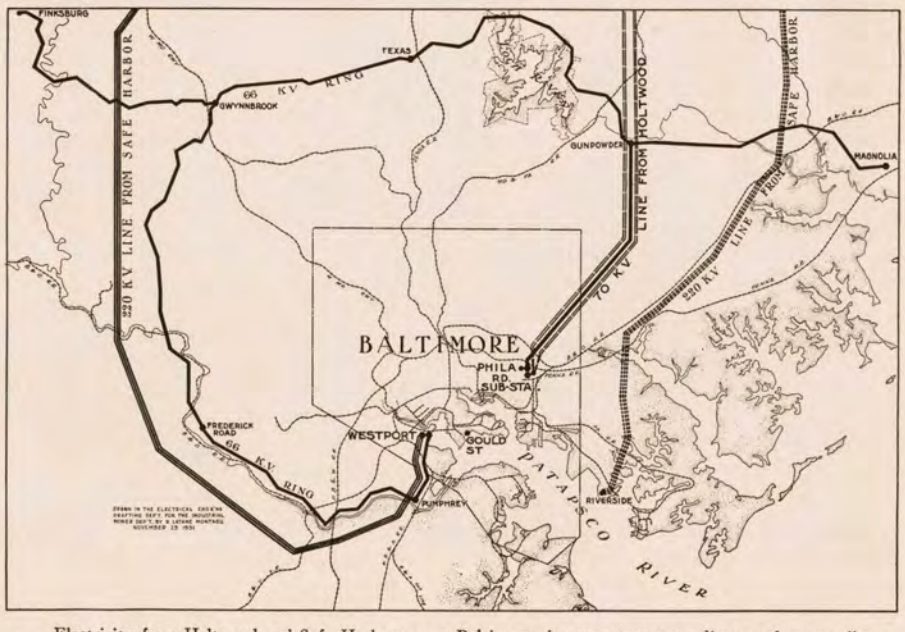
THE DEVELOPMENT AT SAFE HARBOR

The hydro development at Safe Harbor on the Susquehanna River, eight miles above Holtwood, which was placed in operation in 1931 by the Safe Harbor Water Power Corporation, and which is interconnected with the Consolidated System. The present installation at Safe Harbor is 212,500 horse-power, which will ultimately be increased to 510,000 horse-power. The Safe Harbor Water Power Corporation is owned jointly by the Consolidated Gas Electric Light and Power Company of Baltimore and the Pennsylvania Water & Power Company.



Map showing the 70,000-volt line which brings power from the development at Holtwood, on the Susquehanna, to Baltimore, and the new 220,000-volt line now under construction to connect the Consolidated system with the new hydroelectric development at Safe Harbor. The 220,000-volt line, which will approach Baltimore to the east of the city, is scheduled for construction in 1933.





Electricity from Holtwood and Safe Harbor comes Baltimore city over two tower lines, and eventually a third, as indicated by the broken line on this map, will be erected. Circling the city and affording high-tension distribution is the 66,000-volt ring.

PART III

THE EDISON THREE-WIRE SYSTEM FOR DIRECT CURRENT DISTRIBUTION

EARLY ELECTRICAL DISCOVERIES

* "Electricity is one of the most wonderful forces placed ready for the service of mankind; yet it's one of the things which hid its secret longest from us. It can light a city, supply power for lifting the heaviest weights, drive trains and trolleys, cook a dinner, heal a sick child, and kill us if we're not careful." It was first discovered by a Greek named Thales (700 B.C.,) who noticed the magnetic effects of amber when rubbed with another material. From the Greek name of amber,"Elektron", Dr. Gilbert (1540-1603) gave the name "electricity" to the condition which heat and friction excited in similar circumstances. Otto von Guericke (1602-1686) of the Madgeburg Sphere fame, and Sir Isaac Newton further developed the uses of this magnetic property and Francis Hawksbee directed attention to the similarity of sparks produces by rubbing a glass cylinder with silk to lightning.

FIRST ELECTRIC TRANSMISSION

Stephen Gray, a Bluecoat boy in London, at the beginning of the 18th century initiated electric transmission by sending a current created by friction through 886 feet of pack-thread. His experiments were further developed by a Frenchman, Du Fay (1699-1739) who found that electricity is of two kinds, positive and negative.

LEYDEN JAR

The Leyden Jar was made in Holland (1745) simultaneously by a monk named Cunaeus, an inventor named von Kleist, and a University of Leyden professor named van Musschenbroeck, and was perfected in England by Sir William Watson. Results of this creation proved that the action of electricity is instantaneous, a significant fact.

* Book of Knowledge

About this time (1752) Benjamin Franklin (1706-1790) performed his famous kite experiment proving that lightning is electricity. He also found that some clouds are charged with positive electricity and some negative.

Alessandra Volta (1745-1826) in 1800 gave the world his Voltaic Cell; later, Sir Humphrey Davy (1778-1829) with his Royal Institution battery of 2,000 cells produced an electric arc between two carbons; and in 1831 Michael Faraday (1791-1867) discovered the principles of the magneto-machine, which was the forerunner of the modern dynamo.

THOMAS ALVA EDISON

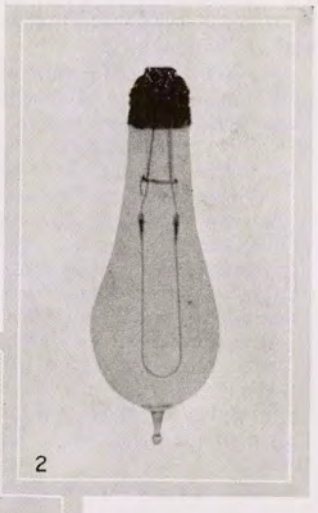
Although these men, and others, discovered electrical phenomena and applied them in elementary experiments, its capabilities were utilized to the fullest extent by Thomas Alva Edison (1847-1931), the "Wizard of Menlo Park". Probably no other individual has done so much to lighten man's work, prolong the daylight into his leisure time, and, in general, provide for a more comfortable and enjoyable existence.

* "Within the span of Edison's life practically the whole electrical development as exemplified in central station generation has occurred. Light at the touch of a button, power at the throw of a switch, when, where and as wanted, are commonplaces of our daily lives. Yet these forces have so altered the way of doing the world's work that life has been made brighter, healthier, happier for millions of people of all races, of all colors, of all creeds."

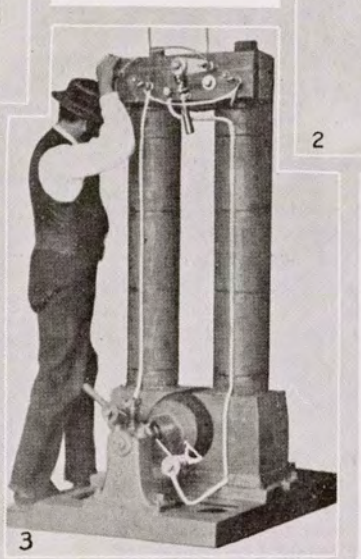
When Edison first became interested in electric light he realized immediately that the light was too bright, and too big. What people wanted was "little lights, and a distribution of them to people's

* Baltimore Gas and Electric News.

1. The first successful incandescent lamp, produced October 21, 1879; showing the filament in its original and treated condition, a section of the socket and the fixture in which it was used.

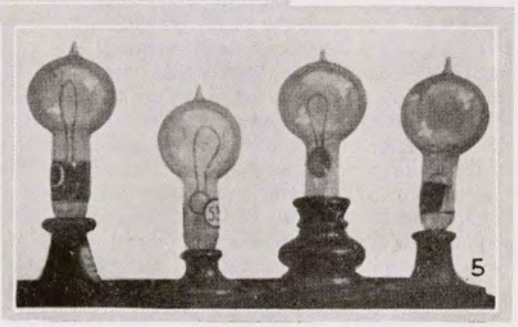


2. The first bamboo filament lamp, marking the first substantial commercial improvement.



3. One of the original Edison Type Z dynamos, for the supply of incandescent lighting.

4. The first electric fixture ever made for the incandescent lamp, made of wood and used by Mr. Edison at the Menlo Park Demonstration.



5. A few of the original incandescent lamps, hand made.

(From an Early Issue of The Baltimore Gas Electric News)

houses." Financed by Grovernor P. Lowry the Edison Electric Light Company was formed to effect these results.

THE INCANDESCENT LAMP

Almost immediately the idea of developing the arc lamps was abandoned in favor of the idea of the incandescent lamp. An account of the experimentation in developing satisfactory filaments for practical use is a history within itself. Platinum alloys with oxide coatings, carbonized cotton thread, bamboo and other materials were tried separately and in numerous combinations, until the carbon filament (later replaced by tungsten) was finally accepted as the ideal material.

THE CENTRAL STATION IDEA

But even with a suitable lamp available the great problem of universal electric light was yet unsolved--that of distribution. The idea originated with Edison and under his supervision plans were pursued and necessary investigations of demand were made. The first central electric supply station began operation September 4, 1882 at the famous Pearl Street location in New York. Electric current generated by a dynamo of his own design, distributed over a system of his own conception burned lamps of his own invention.

CURRENT MEASURING DEVICES

The following extract from the Life History of Thomas Alva Edison by Francis Arthur Jones tells in an interesting manner how current was first measured. "As to voltmeters", states the inventor, "We didn't have any. We used lamps. And I hadn't much use for mathematicians either, for I soon found that I could guess a good deal closer than they could figure, so I went on guessing. We used to hang up a shingle nail, tie it on a string alongside one of the feeders, and use that for a heavy

current ammeter. It worked all right. When the nail came close to the feeder we screwed up the rheostat a little, and in this way kept the lamps looking right ...

Many experiments were made with all sorts of mechanism, motors, clockwork, electro-magnets, springs, heat, electrolysis, and electro-deposition. Finally the Edison meter was evolved, and was found to answer perfectly. It consists of a small glass cell, containing a solution in which two zinc plates are immersed. A certain proportion of the current entering the building is diverted through this combination, and an electro-plating action is set up in the cell, zinc being deposited on one plate from the other. According to a well-known scientific law, a current of certain strength will deposit just so much zinc in a given time, no more and no less. Therefore, it is easy to see that if the plates are periodically weighed, the amount of current supplied between the times of weighing can be calculated to a nicety."

EDISON'S IDEAS UNCHANGED

It is interesting to note that the voltage on the ordinary incandescent electric lamp has remained about the same as that used on Edison's first lights, that the pear-shaped bulb first selected has continued in use, and that the Edison three-wire network now supplies Baltimore's downtown section.

ELECTRICITY IN BALTIMORE

The first current used for lighting purposes in Baltimore was alternating 25 cycle current at low voltage: that, for power was direct current at 500 volts. The town was small and compact, so power was just distributed by overhead wiring. 25 cycle current was unsatisfactory for lighting purposes so in 1904 the McClellan Street Station was erected to

feed the newly installed Edison three-wire network, which covered what is now the whole downtown business section. The same year all overhead transmission and distribution system in the fire zone was destroyed by the Baltimore fire of February 7.

Direct current low-tension systems find their principal field of application in the business and thickly settled residential districts of large cities. Lighting service in theaters, power for elevators, and loads of this nature demand a continuous and reliable source of energy supply.

In early current distribution in Baltimore the overhead distribution system was unsightly and impracticable in a large city and as yet no A. C. system was found that could replace the D. C. net. With the numerous feeders and constantly varying load adequate devices were not yet invented or perfected to prevent trouble. So the Edison Three-Wire underground network for D. C. distribution was used.

THE EDISON THREE-WIRE SYSTEM

The new system (illustrated) consisted of a network of three-wire conduit with a member in almost every street and a feeder junction box at most intersections, so that there was in effect a positive net, a negative net, and a neutral net covering the zone. Now these members ran together in the same conduits but were separate individual cables, the neutral being a small bare wire while the two "outside" wires were 2,000,000 circular mil stranded wire, paper insulated and lead shielded. (See illustration)

The system originates in a power generating plant (hydro- or steam) supplying any number of sub-stations over high tension lines.


Franklin Sta.
McClellan St. Sta.
Custom House Alley Sta.
Sharp St. Sta.
BASIN
■ - Stations now feeding the D.C. net
- New A.C. network territory

Each sub-station steps the voltage down to a lower value to send to various plants or small transformer stations. If it is to supply a network as described above rotary converters rectify the A. C. to D. C. and send it to a station "bus line". From this bus feeders lead to various junctions of the network. As they leave the sub-station they are numerous and require an enormous duct to carry them. Then, as they pass on through the network they are led off, one by one, to the various junctions in the network.

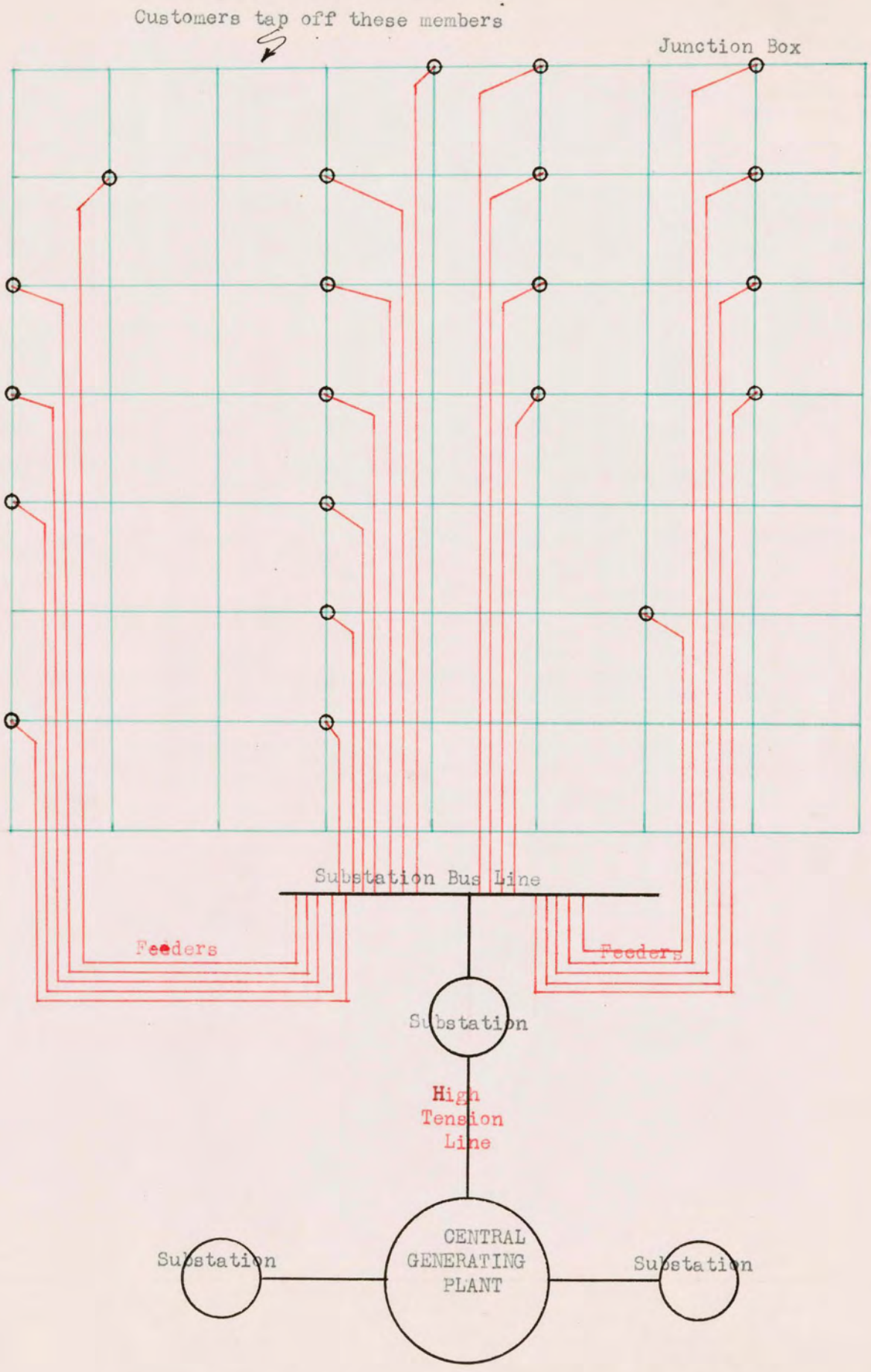
MANHOLE AND DUCT SYSTEM

This system for distribution is housed in what is known as the manhole and duct system. The three cables are lead through ducts to manholes (7'0" x 3'6" and 4'4½"high) located at most intersections. Where feeders tie into the net, junction boxes are placed on the walls of the manholes and are equipped with open link, copper, or alloy fuses. To eliminate incorrect opening of feeder lines, a system of pilot-wire protection for feeders was devised which opened the feeder only in case the fault was in the feeder itself. To protect the entire network each section (say a city block) is fused, so that if a fault occurs in it, only that part of the system is cut off.

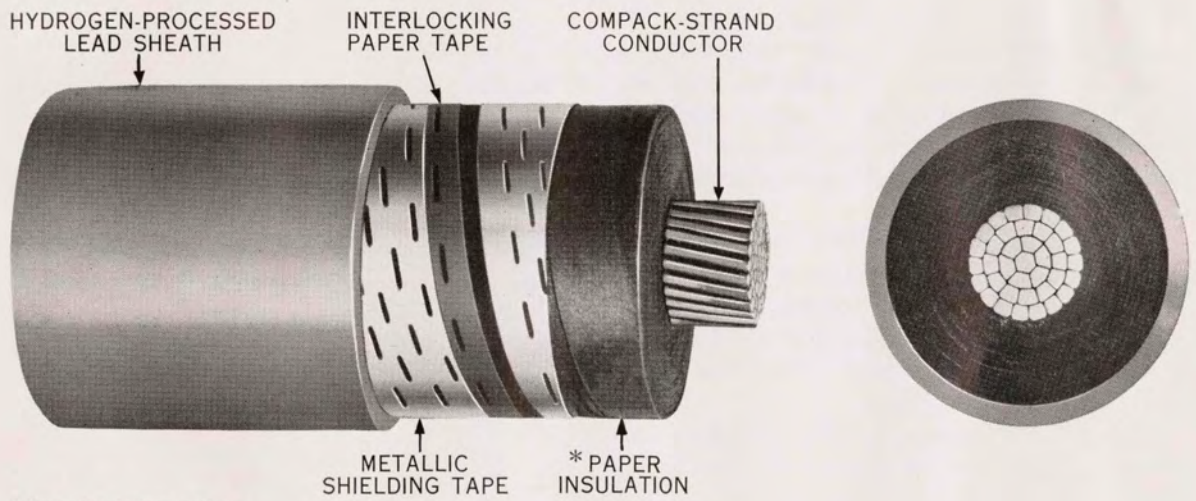
Ordinary lighting loads are tapped directly from these sections, but if an industrial plant, hospital or some such customer be supplied, a feeder may run directly to their supply in addition to the tapped mains.

CONCENTRIC CABLE

Concentric wire cable was available in which both positive and negative lines are in one cable. It resembles the type shown except that strand wire was wrapped cylindrically about the insulated central



EDISON THREE-WIRE SYSTEM FOR DIRECT CURRENT DISTRIBUTION



* Paper insulation applied in graduated layers and treated with CO_2 gas.

Fig. 12
(Photo. No. 494650)

Single-conductor, shielded, Type H, paper-insulated cable

conductor forming the other conductor. In cross section it would look the same except that a circle of wire ends would be seen midway of the insulation between the center conductor and the metallic coating.

The concentric cable would work all right, but was unsatisfactory in locating faults. If, for instance, a fault occurs somewhere in the line current may leak from the copper wire to the lead cable (in the single conductor cable) and "burn clear". On the other hand, in the concentric cable the burn may be from copper to copper and may continue for quite a distance and do extended damages to the network instead of making a point fault as in the single conductor type.

BATTERY SERVICE

As stated above, much of the service in the business district must be continuous and reliable. Such service is impossible from generators where a continuously changing load is on the line, because the speed of the generator would have to be regulated to do so. So a huge storage battery is "floated" on the system.

Storage batteries fulfill four requirements when "floated" on central station systems. First, there is a maximum load for only about one hour or two during the day. This is not enough to justify boosting the generators, and the battery is the most satisfactory of the many schemes devised to supply the extra energy.

Second, there are a few minimum load hours when low capacity operation of generators is uneconomical, from the standpoint of operating efficiency and also manpower. Sometimes an entire shift can be eliminated by the use of batteries.

Third, it is impossible to generate constant power supply when the load is constantly changing. A battery floating on the line will deliver immediately with increased load and absorb the charge on decreased load, giving the system the necessary versatility.

Finally, there are small annex stations where the entire load can be more economically supplied from a battery than from generating equipment. Mention is made in another section of this thesis of various battery installations in Baltimore service.

THE DECLINE OF D. C. DISTRIBUTION

As the city expanded it outgrew direct current distribution. Line losses are great over long transmission distance unless high voltage (60,000-100,000 volts) is used. High voltage D. C. is uneconomical, and if alternating current is to be transmitted rotary converters or mercury arc rectifiers must transform it to direct current to supply it to the network. This machinery, however, is less efficient and more expensive than transformers, so A. C. distribution was experimented with in an attempt to satisfy the ever increasing needs of a growing city.

As a result of experimentation a three-wire network has been devised and is being installed over 70% of the A. C. area in Baltimore's downtown section. The Consolidated Electric Company does not intend, of course, to junk their $12,000,000 worth of D. C. machinery and its distribution system, but the cheaper and more satisfactory alternating current machinery is used in all new installation and where possible replaces faulty D. C. apparatus.

The general trend seems to be the abandonment of direct current distribution in large cities.

BIBLIOGRAPHY

EDISON THREE-WIRE SYSTEM

Electric System Handbook- Clarence H. Sanderson

HISTORY, CUTS, & INSTALLATIONS

Publications of the Consol. G. E. L. & P. Co. of Baltimore City:

The Baltimore Gas and Electric News

Power Pictorial

Gas Centenary 1816-1916

Blue Book #5-"The Company's Electric System During 25 Years"- Richard H. Lang, Chief Operator, Electric Stations Department.

Annual Report and Year Book

The Consol. G. E. L. & P. Co. and Its Constituent Companies- Charters, Mortgages, and Releases

ELECTRICAL HISTORY

Book of Knowledge

Encyclopoedia Britanica

Life History of Thomas Alva Edison- Francis Arthur Jones

Edison, The Man and His Work- George S. Bryan